Treatment of multiple lingual gingival recession defects in mandibular incisors with modified coronally advanced tunnel technique and connective tissue graft: A case series

Vikender Singh Yadav,[1] Priyanka Kamra,[1] Deepti,[1] Nisha Singh,[1] Anu Bhatia[1] and Renu Yadav[2]

[1]Division of Periodontics, Centre for Dental Education and Research, All India Institute of Medical Sciences, New Delhi, India; [2]Department of Prosthodontics, Surendera Dental College and Research Institute, Sriganganagar, Rajasthan, India

Abstract

Aim: Evidence for the treatment of lingual recession defects is scarce. The aim of this case series was to investigate the clinical efficacy of modified coronally advanced tunnel (MCAT) technique in combination with connective tissue graft (CTG) for the treatment of multiple lingual gingival recessions.

Materials and methods: Six patients with a total of 20 adjacent RT1 and RT2 lingual recession defects in mandibular incisors were treated with MCAT + CTG. Clinical parameters were recorded at baseline and 6 months. Patient-centred outcomes (dentinal hypersensitivity and postoperative pain) were also assessed.

Results: Postoperative course of healing was uneventful in all patients. At 6 months, significant recession depth reduction (2.45 ± 0.51 mm), keratinized tissue width gain (1.10 ± 0.55 mm) and increase in gingival thickness (0.91 ± 0.34 mm) were observed. Mean root coverage was 79.35% and complete root coverage was achieved in 40% of treated recession defects. All patients reported a significant reduction in dentinal hypersensitivity at the end of the study period.

Conclusion: Tunnel technique in combination with CTG is a safe and predictable approach for root coverage in multiple lingual recessions in mandibular incisors. However, further studies of longer duration in large number of patients are needed to support these findings.

Keywords: Connective tissue graft, dentin hypersensitivity, root coverage

Introduction

Gingival recession (GR) may affect single or multiple teeth resulting in exposure of the root on one or more surfaces. The literature is replete with clinical trials and studies related to surgical treatment of facial GR, particularly in isolated defects but published documentation on lingual recession defects is limited. The consensus report from American Academy of Periodontology Regeneration Workshop also addressed the need for future research on treatment of GR in multiple defects and at lingual/palatal sites (Tatakis *et al*., 2015).

Several factors have been associated with GR (Zucchelli and Mounssif, 2015), but a relatively higher prevalence and severity of GR on the lingual surface of mandibular anteriors (incisors and canines) is ascribed to poor oral hygiene (Loe *et al*., 1992; Marini *et al*., 2004). A positive association between the amount of calculus and degree of GR has been observed (van Palenstein Helderman *et al*., 1998; Rustogi *et al*., 1991). Tongue piercing, poorly constructed removable partial dentures, full coverage restorations with intracrevicular margins, and orthodontic therapy can be other contributing etiological factors (Campbell *et al*., 2002; Assis *et al*., 2017; Kim and Neiva, 2015).

Although aesthetics is not a primary concern, the rationale for treating lingual recession defects is to facilitate plaque control, improve patient comfort by

Correspondence to: Dr. Vikender Singh Yadav, Division of Periodontics, Centre for Dental Education and Research, All India Institute of Medical Sciences, New Delhi, India-110029.
E-mail Address: vikenderyadav@gmail.com

alleviating dentinal hypersensitivity (DH) and prevent the progression of GR (Kim and Neiva, 2015). Furthermore, gingival augmentation i.e. increase in thickness and width of keratinized tissue through root coverage procedures improves long-term stability of affected teeth (Agudio *et al*., 2016). This is of particular relevance in GR of mandibular incisors in which total root surface area of attachment is comparatively less than the other teeth (Park *et al*., 2017). Considering the fact that untreated recession defects continue to progress with time (Chambrone and Tatakis, 2016) resulting in deprivation of supporting structures, root coverage in this area is therefore indicated and desirable.

Several surgical techniques and biomaterials have been introduced to predictably achieve the goals of root coverage in single and multiple teeth (Cairo, 2017). Nevertheless, successful treatment of multiple recession defects is relatively more demanding for both the clinician and patient, considering the larger avascular recipient site, differences in recession depths, position of teeth, longer duration of surgery and postoperative morbidity (Cairo, 2017; Aroca *et al*., 2010). Lingual recession defects represent an additional challenge for the clinicians as evidence for decision making to treat such defects is still not clear. Among various surgical approaches, modified coronally advanced tunnel (MCAT) technique offers the advantages of faster wound healing and revascularization at surgical site by obviating vertical incisions and not incising the papillary tissues (Zuhr *et al*., 2018). Numerous clinical studies have also demonstrated the predictable outcomes with this technique in combination with connective tissue graft (CTG) or soft tissue substitutes in multiple facial Miller's Class I, II and III GR defects (Tavelli *et al*., 2018). However, the literature is lacking with regard to MCAT technique for treatment of multiple lingual recession defects.

Therefore, the purpose of this case series was to share the clinical and patient reported outcomes following treatment of multiple adjacent lingual recession defects in mandibular incisors utilizing MCAT technique in conjunction with CTG.

Materials and methods

Study Population

Six adult patients who were referred to the Division of Periodontics with a chief complaint of DH and/or receding gums were consecutively enrolled in the present case series based on the following inclusion criteria (1) age ≥ 18 years (2) systemically healthy subjects without any contraindication for periodontal surgery (3) absence of an active periodontal disease (4) presence of atleast two adjacent RT1 or RT2 lingual GR defects in mandibular anteriors with an identifiable cementoenamel junction (CEJ) and recession depth of ≥ 2 mm (5) full mouth plaque score (FMPS) and full mouth bleeding score (FMBS), both <20%. Subjects were excluded from the study if they were current smokers, pregnant or lactating, taking medicines which could affect periodontal tissues and wound healing, undergoing fixed or removable orthodontic therapy, and not compliant with plaque control regimen. Written informed consent was obtained from all the patients after explaining the purpose of study and risks and benefits associated with the surgical procedure. All procedures were done in accordance with the Declaration of Helsinki of 1975, as revised in 2013.

Initial Therapy and Clinical Measurements

All subjects received individualized oral hygiene instructions and full-mouth supragingival scaling and polishing one month prior to scheduled surgery. The following clinical parameters were recorded to the nearest millimetre (mm) at mid-lingual surface of the involved teeth with a calibrated periodontal probe (UNC-15, Hu Friedy Mfg. Inc, Chicago, IL, USA): (1) recession depth (RD) measured from CEJ to gingival margin; (2) probing depth (PD) measured from free gingival margin to most apical part of the sulcus; (3) clinical attachment level (CAL) calculated as sum of PD and RD; (4) keratinized tissue width (KTW) as distance from gingival margin to mucogingival junction. Gingival thickness (GT) was measured mid-lingually with an endodontic spreader and rubber endodontic stopper inserted perpendicular to gingival tissues 3 mm apical to gingival margin using a digital caliper.

A single calibrated examiner (PK) assessed all the clinical measurements at baseline and after 6 months of treatment. Intraexaminer reproducibility was determined with a calibration exercise for PD and RD in five non-study patients on two occasions, 48 hours apart. Calibration was accepted if > 90% of the recordings could be reproduced within a difference of 1.0 mm for both the parameters.

Patient-Centered Outcomes

DH was assessed at baseline and 6 months after surgery on visual analogue scale (VAS) scale (0 = no pain; 10 = extreme pain) as reported by patient. Postoperative pain was recorded at 7th day postsurgical follow-up visit on VAS scale (0 = no pain; 10 = extreme pain) based on questionnaire provided to each patient. Patients were also asked to report the number of painkiller tablets taken and postoperative complications, if any.

Surgical Procedure

All surgical procedures were performed by the same operator with high level of expertise (VSY) in root coverage surgeries. Presurgical temporary splinting at interdental contact points of affected teeth was done with flowable

light-curing resin to place the future coronally anchored sutures for flap advancement (Figure 1a). After local anesthesia, mechanochemical debridement of exposed root surfaces was done with Gracey curettes (SG1/2, Hu-Friedy) and tetracycline hydrochloride solution (100 mg/ml for 3 minutes). Tunnel preparation was done as described by Aroca *et al.* (2010). Intrasulcular incisions extending to at least one adjacent tooth on both the sides were made with microsurgical blade on the lingual aspect of affected teeth. Subsequently, mucoperiosteal dissection with tunneling knives (TKN1 and TKN2, Hu-Friedy) was done beyond the mucogingival junction and under each papilla (Figure 1b). Collagen fibers attached on the inner side of the tunneled lingual flap were released with sharp Gracey curettes held parallel and close to the mucosal surface to achieve passive flap mobilization for coronal advancement. Great care was taken to avoid perforation of the tunneled flap and disruption of the interdental papillae during this whole maneuver.

Immediately after completion of the tunnel preparation, a subepithelial CTG of 1.5-2 mm thickness was harvested from the palate with modified single incision technique (Thalmair *et al.*, 2010) (Figure 1c) and primary wound closure was achieved with continuous interlocking suture (4-0 polyglactin 910, Vicryl, Ethicon LLC, Johnson & Johnson, USA). A deepithelialized free gingival graft (DGG) (Zucchelli *et al.*, 2010) (Figure 2b) was however used to obtain CTG in patients with a shallow and/or thin palate. Palatal wound was protected with an oxidized regenerated cellulose (Surgicel, absorbable hemostat, Ethicon LLC, USA) dressing held in place with horizontal sling criss-cross sutures. In all treated cases, dimensions of CTG were sufficient enough to extend to adjacent tooth on both sides.

The CTG was then inserted under the tunneled flap and pulled laterally by positioning sutures towards each end of the tunnel (Figure 1d). Finally, the entire gingivopapillary complex was coronally positioned with vertical mattress sutures (6-0 polypropylene, Prolene, Ethicon LLC, Johnson & Johnson, San Lorenzo, USA) suspended at each splinted contact point (Figure 1e & 2c). No surgical dressing was applied.

Figure 1. MCAT + subepithelial CTG for multiple lingual recessions (a) Preoperative view showing gingival recession on lingual surface of mandibular incisors (b) Tunnel preparation completed under papilla to allow coronal advancement (c) Subepithelial CTG harvested from the palate (d) CTG inserted under the tunneled flap (e) Immediate postoperative view showing coronal advancement of the gingivopapillary complex to cover the graft and recessions (f) Postoperative situation at 6 months

Figure 2. MCAT + DGG for multiple lingual recessions (a) Preoperative view of multiple lingual recessions (b) Connective tissue surface of the deepithelialized palatal graft immediately before insertion into prepared tunnel (c) Postoperative view after surgery to stabilize the graft and tunneled flap in coronal position (d) Clinical situation at 6 months follow-up

Postoperative Care

Each patient was given 400 mg of ibuprofen immediately before surgery and was asked to take the second dose after 6 hours of surgery. Additional tablets were taken only if required. Patients were provided with properly written postsurgical instructions to avoid any mechanical trauma from brushing in operated area and excessive tongue movements for at least 2 weeks. All patients were instructed to rinse with 0.12% chlorhexidine digluconate twice daily for two weeks starting the day after surgery. Palatal sutures were removed after 7 days while sutures at recession treated sites were removed after 14 days of surgery. Thereafter, mechanical cleaning with an extra-soft manual toothbrush was resumed using roll method. No interdental cleaning at treated site was allowed for 4 weeks. Patients were recalled every month for assessment of oral hygiene and professional supragingival cleaning, if needed.

Statistical Analysis

Each recession defect was considered as a statistical unit for clinical parameters while patient was the unit of statistical analysis for patient-centered outcomes. Shapiro-Wilk test was used to determine the normality of data and descriptive statistics were expressed as mean ± standard deviation (SD). The significance of difference for evaluated parameters before and after treatment was evaluated by Wilcoxon signed-rank test. The comparison of variables between RT1 and RT2 defects was analyzed by Mann-Whitney U test. Spearman's correlation coefficient was used to determine the influence of surgical duration on VAS pain scores and analgesic consumption. The level of significance was set at the probability value (p) ≤ 0.05. All statistical analysis was performed using a statistical software package (SPSS, v.19.0 for Windows, IBM, Chicago, IL).

Results

Twenty lingual GR defects (9 RT1 and 11 RT2 defects) were treated in six subjects (2 females; 4 males) with MCAT+CTG. In all patients, recession defects were attributed to calculus deposits and indication for treatment was DH to cold items. All four mandibular incisors in 3 patients, three teeth (two centrals and one lateral incisor) in 2 patients, and both centrals in one patient had GR on lingual surface. The mean age of patients was 35.66 ± 5.50 years (age range: 27-42 years). Baseline FMPS and FMBS were 10.50 ± 1.87 and 11.00 ± 2.36 respectively. The mean duration of the surgical procedure was 90 ± 11.8 minutes. All patients completed the postoperative follow-up period of 6 months (Figure 1f & 2d).

There was a significant improvement in all clinical parameters from baseline to the end of the evaluation period except for PD. The mean recession depth was 3.20 ± 0.76 (range: 2 to 5 mm) and 0.75 ± 0.71 mm (range: 0 to 2 mm) at baseline and final examination respectively (Table 1). The mean percentage of root coverage (mRC) was 79.35 ± 18.46% while complete root coverage (CRC) was achieved in 40% of treated defects. When comparisons were made between RT1 and RT2 defects, there were no significant differences at baseline for any of the clinical parameter. At 6 months, recession depth reduction for RT1 defects was significantly higher compared to RT2 defects (p=0.018) (Table 2). CRC was obtained at six (66.66%) of RT1 defects compared with two (18.18%) of RT2 defects and was statistically significant (p = 0.032) (Table 3).

Mean VAS score for DH was 5.00 ± 0.89 at baseline and significantly reduced to 1.16 ± 0.98 at 6 months (p = 0.02). The treatment was thus effective in achieving significant reduction in DH by approximately 79%. There was complete resolution of DH in two out of six patients. Healing was uneventful in all cases without any complications such as bleeding, flap dehiscence, pus or abscess formation and loss of graft. Mean VAS score for postoperative pain was 5.5 ± 1.04. The mean number of analgesic tablets consumption was 4.16 ± 0.98 (including the preoperative tablet) over a mean duration of 2.3 ±

Table 1. Clinical parameters at baseline and 6 months evaluation (mean ± SD)

Parameter	Baseline	6 months	Difference	P value
Recession depth	3.20 ± 0.76	0.75 ± 0.71	2.45 ± 0.51	< .05
Probing depth	1.80 ± 0.61	1.70 ± 0.47	0.10 ± 0.30	NS
Clinical attachment level	5.00 ± 0.32	2.45 ± 0.51	2.55 ± 0.51	< .05
Keratinized tissue width	1.45 ± 0.60	2.55 ± 0.60	1.10 ± 0.55	< .05
Gingival thickness	0.85 ± 0.26	1.76 ± 0.47	0.91 ± 0.34	< .05

NS= non-significant

Table 2. Comparison of clinical parameters at baseline and 6 months of RT1 and RT2 gingival recessions (mean ± SD)

Parameter	RT1 defects (n=9)			RT2 defects (n =11)			Intergroup difference (P)**	
	Baseline	6 months	Difference (P)*	Baseline	6 months	Difference (P)*	Baseline	6 months
RD (mm)	2.88 ± 0.60	0.33 ± 0.50	.006	3.45 ± 0.82	1.09 ± 0.70	.002	.101***	.018
KT (mm)	1.55 ± 0.72	2.77 ± 0.66	.009	1.36 ± 0.50	2.36 ± 0.50	.002	.597***	.145***
GT (mm)	0.77 ± 0.19	1.69 ± 0.37	.007	0.90 ± 0.30	1.81 ± 0.56	.003	.319***	.661***

RD = recession depth; KTW = keratinized tissue width; GT = gingival thickness.
*Wilcoxon signed rank test; **Mann Whitney U test; ***statistically non-significant

Table 3. Comparison of mean root coverage and complete root coverage of RT1 and RT2 defects

	RT1 defects (n=9)	RT2 (n=11)	P value
Mean root coverage (%)	89.88 ± 15.34	70.72 ± 16.67	.023*
Complete root coverage (%)	66.66	18.18	.032*

*Statistically significant difference, P < .05

1.2 days. A significant positive correlation was observed between postoperative VAS pain scores and number (r = 0.906, p = 0.013) and duration (r = 0.955, p = 0.003) of painkiller tablets taken. Also, there was a significant correlation between surgery duration and VAS pain scores (r = 0.971, p = 0.001) or analgesic consumption (r = 0.926, p = 0.008).

Discussion

Periodontal root coverage procedures are technique-sensitive and outcomes are influenced by the operator's experience. The clinical challenge of treating recession defects in this case series is related to the number and sites of GRs. Soft tissue management in multiple recession defects is more difficult and wound healing may be compromised due to limited blood supply in relation to coverage of wider avascular root surfaces (Cairo, 2017). Lingual recession defects in mandibular incisors further pose a challenge for the clinician from technical and anatomical aspects. Preparation of a partial thickness flap in this region is extremely technique sensitive due to quality of tissues available (thin gingival biotype and narrow zone of KT) and limited surgical accessibility (Wilcko *et al*., 2005). In addition to increased risk of flap perforation with supraperiosteal dissection, a split-thickness flap could not withstand the forces from tongue pull during speech and mastication. A full-thickness flap preparation was therefore preferred in this area. However, reflection of even mucoperiosteal lingual flaps in mandibular anterior region should be performed with extreme caution to avoid damage to the vascular plexus and subsequent formation of sublingual hematoma, a potentially life threatening situation (Fujita *et al*., 2012). An advantage of performing MCAT over other surgical techniques is related to the absence of any surface incisions which improves the vascularity of the flap and graft during healing phases (Zuhr *et al*., 2018). This preservation of blood supply is of particular significance while treating multiple recession defects when there is a large avascular surface and extension of flap increases with every added tooth. Also, it is tempting to speculate that the risk of violating the vascular network may be minimized with "full-thickness", "incision-free" approach. Despite the potential benefits offered by this technique, it requires a high level of dexterity from the clinician.

Results of the present study demonstrated a significant decrease in recession depth with overall mRC of 79.35% (89.88% for RT1 and 70.72% for RT2 defects) and CRC in 40% of the defects after 6 months of surgery. These outcomes are however inferior to those reported in a recent systematic review which demonstrated an mRC of 85.88% and CRC of 61.35% in multiple mandibular Miller class I, II and III recession defects treated with tunnel techniques (Tavelli *et al*., 2018). This can be presumably attributed to poor access for plaque control, postoperative physical trauma during healing phase and pull from tongue musculature which compromises the wound healing and may adversely affect the surgical outcomes in lingual recession defects. Moreover, findings from this review should be interpreted judiciously in reference to the present case series because variations in the root coverage between different studies included can be influenced by the research study design, demographics, smoking behavior of participants, defect-related factors, full versus split thickness tunnel preparation and type of soft tissue graft used. Further, it should be noted that all the clinical studies on tunnel technique for root coverage in multiple teeth are based on buccal recession defects classified as Miller class I, II and III. Evidence for the treatment of multiple lingual GRs is scarce and only limited to case reports (Wilcko *et al*., 2005; Assis *et al*., 2017; Vijay *et al*., 2017; Alves *et al*., 2019). To the best of author's knowledge, this is the first case series to report on the treatment of multiple lingual RT1 and RT2 defects in mandibular incisors with MCAT + CTG. Therefore, a true comparison of the results obtained in present investigation cannot be made with previously published studies.

It needs to be pointed out that none of the patients in the present study exhibited CRC. The most plausible reason for this is the presence of at least one affected tooth with higher initial recession depth (>3 mm) and/or interproximal attachment loss (RT2) in each patient. Complete coverage of the graft is difficult to achieve in deep mandibular recession defects, particularly with tunnel procedures (Tavelli *et al*., 2018). Therefore, partial root coverage in recession defects with a depth of ≥3 mm in present case series presumably has been attributed to necrosis of the exposed portion of the graft covering the root. Also, interproximal attachment level (Cairo *et al*., 2011) is considered a strong predictive factor for final root coverage after different surgical procedures, though CRC has been reported in few cases of published studies on facial Miller class III or RT2 defects (Aroca *et al*., 2010; Cairo *et al*., 2012; Esteibar *et*

al., 2011) as in present case series. Additionally, the role of previously described factors which compromise the wound healing at lingual recession sites and limits the amount of root coverage cannot be underestimated.

It should be understood that root coverage procedures are not only aimed at achieving CRC and improving aesthetics, but also to increase the width and thickness of keratinized tissues and relief from DH. Sufficient KT dimensions are critically important in lingual region to facilitate plaque removal with routine oral hygiene measures and resist the routinely subjected physical insults. A statistically significant gain of 1.10 ± 0.55 mm for KTW and 0.91 ± 0.34 mm for GT was achieved in present case series. These findings are comparable to those reported by Thalmair *et al.* (2016) evaluating tunnel technique and CTG in multiple mandibular anterior GRs, but on facial surface. All patients reported a significant decrease in DH as reflected by lower VAS scale values at 6 month follow-up. This is likely to result from soft tissue coverage of the previously exposed root surface and improved ability of the patients for mechanical plaque control.

Positive treatment outcomes such as root coverage and gain in KT dimensions in this case series are also attributed to the use of CTG. Increase in KTW may be speculated to result from keratinization of exposed portion of graft (Kahnberg and Thilander, 1982) or the capability of CTG to induce epithelial differentiation of the overlying flap during initial phases of wound healing (Karring *et al*., 1975). The presence of CTG under tunneled flap provides support to the elevated papilla and gingival margin resulting in an increase of marginal soft tissue thickness while also minimizing the chances of collapse of interdental papilla during healing (Aroca *et al*., 2018). Postoperative increase in GT is associated with stability and coronal shift of gingival margin in long term (Pini-Prato *et al*., 2010). Some amount of recession reduction can be expected to result from creeping attachment at further follow-up visits.

Volumetric changes in soft tissues after surgical treatment of GRs could have been evaluated more precisely by superimposition technique using an optical scan (Alves *et al*., 2019). Limited sample size; shorter duration and lack of control group were other limitations.

Conclusion

Within limitations of this case series, MCAT with CTG appears to be an effective surgical approach for treatment of multiple lingual recession defects in mandibular incisors. However, additional studies with a large sample size and long-term follow up should validate the preliminary findings presented here. Future comparative studies with different surgical approaches and in teeth other than incisors are also necessary to generate evidence for management of lingual recession defects.

Acknowledgements

None

Conflict of interest

The authors have no conflict of interest.

Sources of financial support

None

References

Agudio G, Cortellini P, Buti J and Pini Prato G. Periodontal conditions of sites treated with gingival augmentation surgery compared with untreated contralateral homologous sites: an 18- to 35-year long-term study. *Journal of Periodontology* 2016; **87**:1371-1378.

Alves JP, Marques TM, Malta Santos NB, *et al.* Lingual incision subperiosteal tunnel access: proof of concept 18-month follow-up. *Clinical Advances in Periodontics* 2019; **9**:196-202.

Aroca S, Barbieri A, Clementini M, Renouard F and de Sanctis M. Treatment of class III multiple gingival recession defects: Prognostic factors for achieving a complete root coverage. *Journal of Clinical Periodontology* 2018; **45**:861-868.

Aroca S, Keglevich T, Nikolidakis D, *et al.* Treatment of class III multiple gingival recessions: a randomized-clinical trial. *Journal of Clinical Periodontology* 2010; **37**:88-97.

Assis G, Nevins M and Kim DM. The use of autogenous gingival graft for treatment of lingual recession on mandibular anterior teeth. *The International Journal of Periodontics & Restorative Dentistry* 2017; **37**:667-671.

Cairo F, Cortellini P, Tonetti M, *et al.* Coronally advanced flap with and without connective tissue graft for the treatment of single maxillary gingival recession with loss of inter-dental attachment. A randomized controlled clinical trial. *Journal of Clinical Periodontology* 2012; **39**:760-768.

Cairo F, Nieri M, Cincinelli S, Mervelt J and Pagliaro U. The interproximal clinical attachment level to classify gingival recessions and predict root coverage outcomes: an explorative and reliability study. *Journal of Clinical Periodontology* 2011; **38**:661-666.

Cairo F. Periodontal plastic surgery of gingival recessions at single and multiple teeth. *Periodontology 2000* 2017; **75**:296-316.

Campbell A, Moore A, Williams E, Stephens J and Tatakis DN. Tongue piercing: impact of time and barbell stem length on lingual gingival recession and tooth chipping. *Journal of Periodontology* 2002; **73**:289-297.

Chambrone L and Tatakis DN. Long-term outcomes of untreated buccal gingival recessions: a systematic review and meta-analysis. *Journal of Periodontology* 2016; **87**:796-808

Esteibar JR, Zorzano LA, Cundín EE, Blanco JD and Medina JR. Complete root coverage of Miller Class III recessions. *The International Journal of Periodontics & Restorative Dentistry* 2011; **31**:1-7.

Fujita S, Ide Y and Abe S. Variations of vascular distribution in the mandibular anterior lingual region: a high risk of vascular injury during implant surgery. *Implant Dentistry* 2012; **21**:259-264.

Kahnberg KE and Thilander H. Healing of experimental excisional wounds in the rat palate. (I) Histological study of the interphase in wound healing after sharp dissection. *International Journal of Oral Surgery* 1982; **11**:44-51.

Karring T, Lang NP and Loe H. The role of gingival connective tissue in determining epithelial differentiation. *Journal of Periodontal Research* 1975; **10**:1-11.

Kim DM and Neiva R. Periodontal soft tissue non-root coverage procedures: a systematic review from the AAP Regeneration Workshop. *Journal of Periodontology* 2015; **86**:56-72.

Loe H, Anerud A and Boysen H. The natural history of periodontal disease in man: prevalence, severity, and extent of gingival recession. *Journal of Periodontology* 1992; **63**:489-495.

Marini MG, Greghi SL, Passanezi E and Santana AC. Gingival recession: prevalence, extension and severity in adults. *Journal of Applied Oral Science* 2004; **12**:250-255.

Park SB, An SY, Han WJ and Park JT. Three-dimensional measurement of periodontal surface area for quantifying inflammatory burden. *Journal of Periodontal & Implant Science* 2017; **47**:154-164.

Pini-Prato GP, Cairo F, Nieri M, *et al.* Coronally advanced flap versus connective tissue graft in the treatment of multiple gingival recessions: a split-mouth study with a 5-year follow-up. *Journal of Clinical Periodontology* 2010; **37**:644-650.

Rustogi KN, Triratana T, Kietprajuk C, Lindhe J and Volpe AR. The association between supragingival [correction of subgingival] calculus deposits and the extent of gingival recession in a sample of Thai children and teenagers. *Journal of Clinical Dentistry* 1991; **3**:6-11.

Tatakis DN, Chambrone L, Allen EP, *et al.* Periodontal soft tissue root coverage procedures: a consensus report from the AAP Regeneration Workshop. *Journal of Periodontology* 2015; **86**:52-55.

Tavelli L, Barootchi S, Nguyen TVN, *et al.* Efficacy of tunnel technique in the treatment of localized and multiple gingival recessions: a systematic review and meta-analysis. *Journal of Periodontology* 2018; **89**:1075-1090.

Thalmair T, Fickl S and Wachtel H. Coverage of multiple mandibular gingival recessions using tunnel technique with connective tissue graft: a prospective case series. *The International Journal of Periodontics & Restorative Dentistry* 2016; **36**:859-867.

Thalmair T, Fickl S, Hinze M, Bolz W and Wachtel H. Modifizierte Technik zur Entnahme eines subepithelialen Bindegewebstransplantates. *Parodontologie* 2010; **21**:100–105.

Van Palenstein Helderman WH, Lembariti BS, van der Weijden GA and vant Hof MA. Gingival recession and its association with calculus in subjects deprived of prophylactic dental care. *Journal of Clinical Periodontology* 1998; **25**:106–111.

Vijay KM, Triveni MG, Kumar ABT and Mehta DS. Minimally invasive treatment of mandibular anterior lingual defects by vestibular incision subperiosteal tunnel access technique and connective tissue graft: a case report. *Clinical Advances in Periodontics* 2017; **7**:195-200.

Wilcko MT, Wilcko WM, Murphy KG, *et al.* Full-thickness flap/subepithelial connective tissue grafting with intra marrow penetrations: three case reports of lingual root coverage. *The International Journal of Periodontics & Restorative Dentistry* 2005; **25**:561-569.

Zucchelli G and Mounssif I. Periodontal plastic surgery. *Periodontology 2000* 2015; **68**:333-368.

Zucchelli G, Mele M, Stefanini M, *et al.* Patient morbidity and root coverage outcome after subepithelial connective tissue and de-epithelialized grafts: a comparative randomized-controlled clinical trial. *Journal of Clinical Periodontology* 2010; **37**:728-738.

Zuhr O, Rebele SF, Cheung SL and Hurzeler MB. Surgery without papilla incision: tunneling flap procedures in plastic periodontal and implant surgery. *Periodontology 2000* 2018; **77**:123-149.